Science and Engineering Practices in the Classroom

Building Capacity in Science Instruction through the Framework for K-12 Science Education

A Workshop for Science Educators and Leaders
Presented by Utah Office of Education
Dixie State University
and
Partnership for Effective Science Teaching and Learning

Dixie State University Conference Center
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Presenter: Brett Moulding,
Director Partnership for Effective Science Teaching and Learning

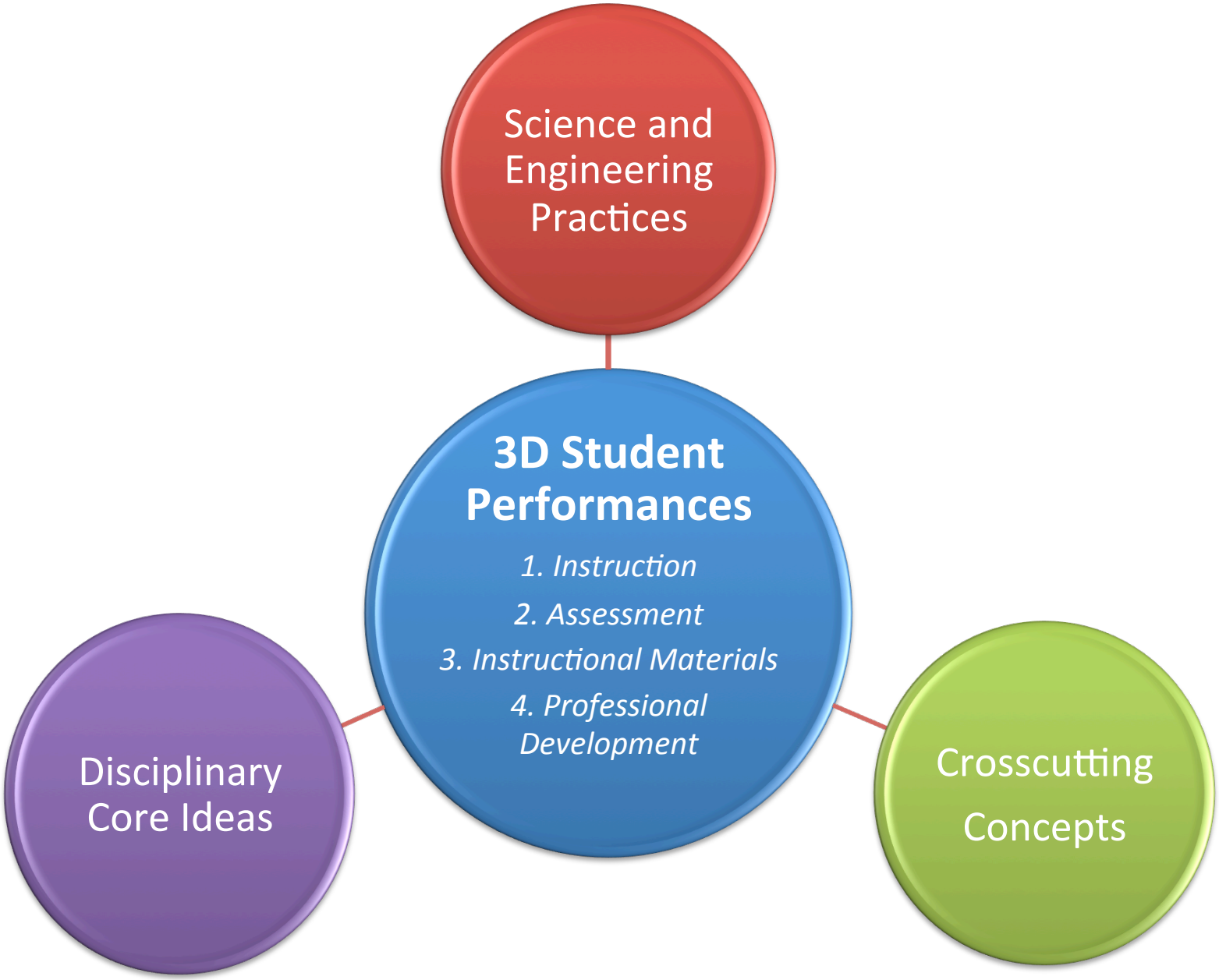
Overview

- Science and Engineering Practices
- Science Performances
- Why Standards?
- Closure and Discussion

Performances @ Intersection of 3 Dimensions

- Core Ideas have historically been used as the outcome of science instruction.
- The *Framework's* vision is for Core Ideas being used as evidence in the reasoning aspect of the performance at the intersection of three dimensions.

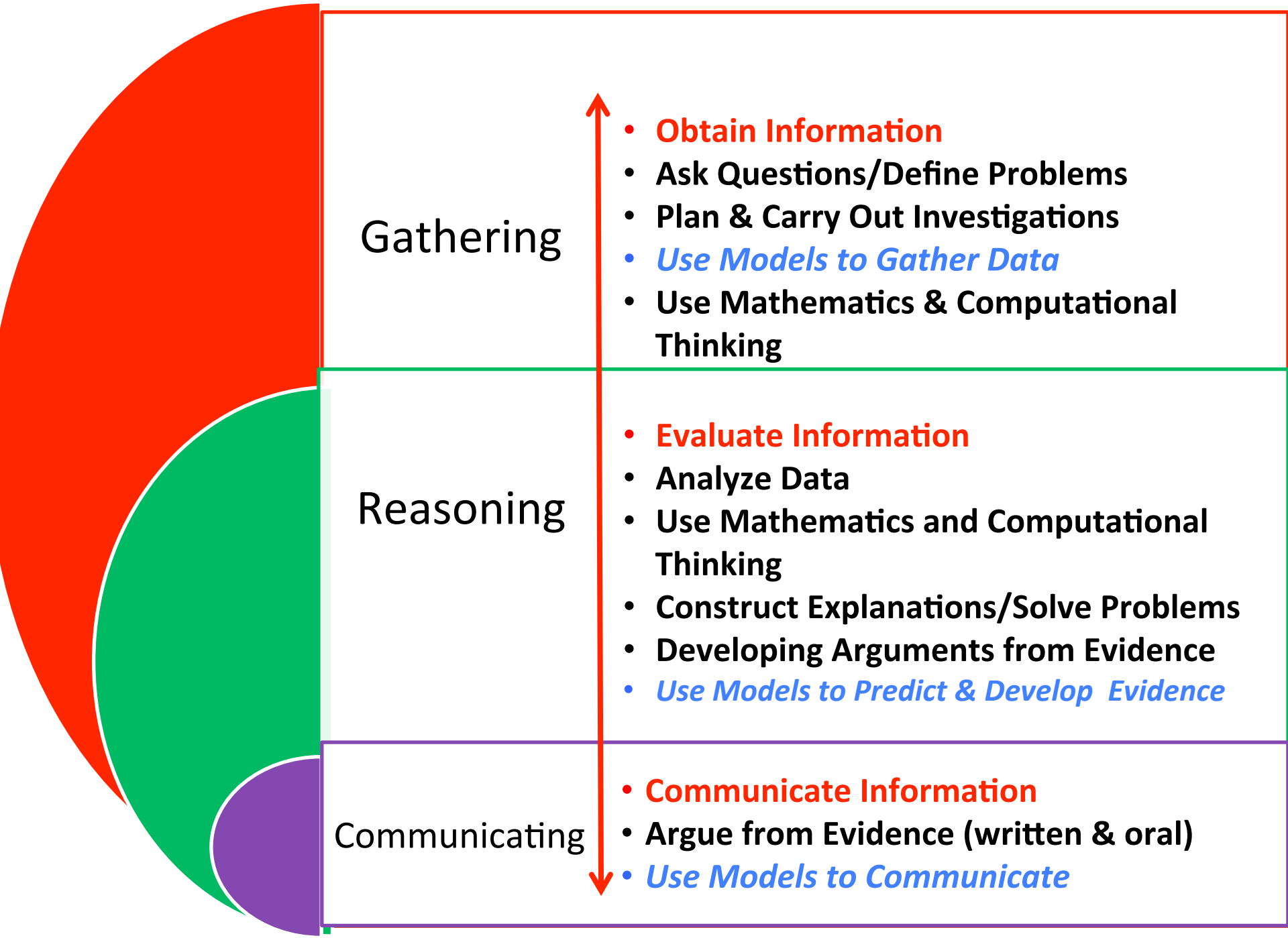
3-D Model = Science Performance at the Intersection



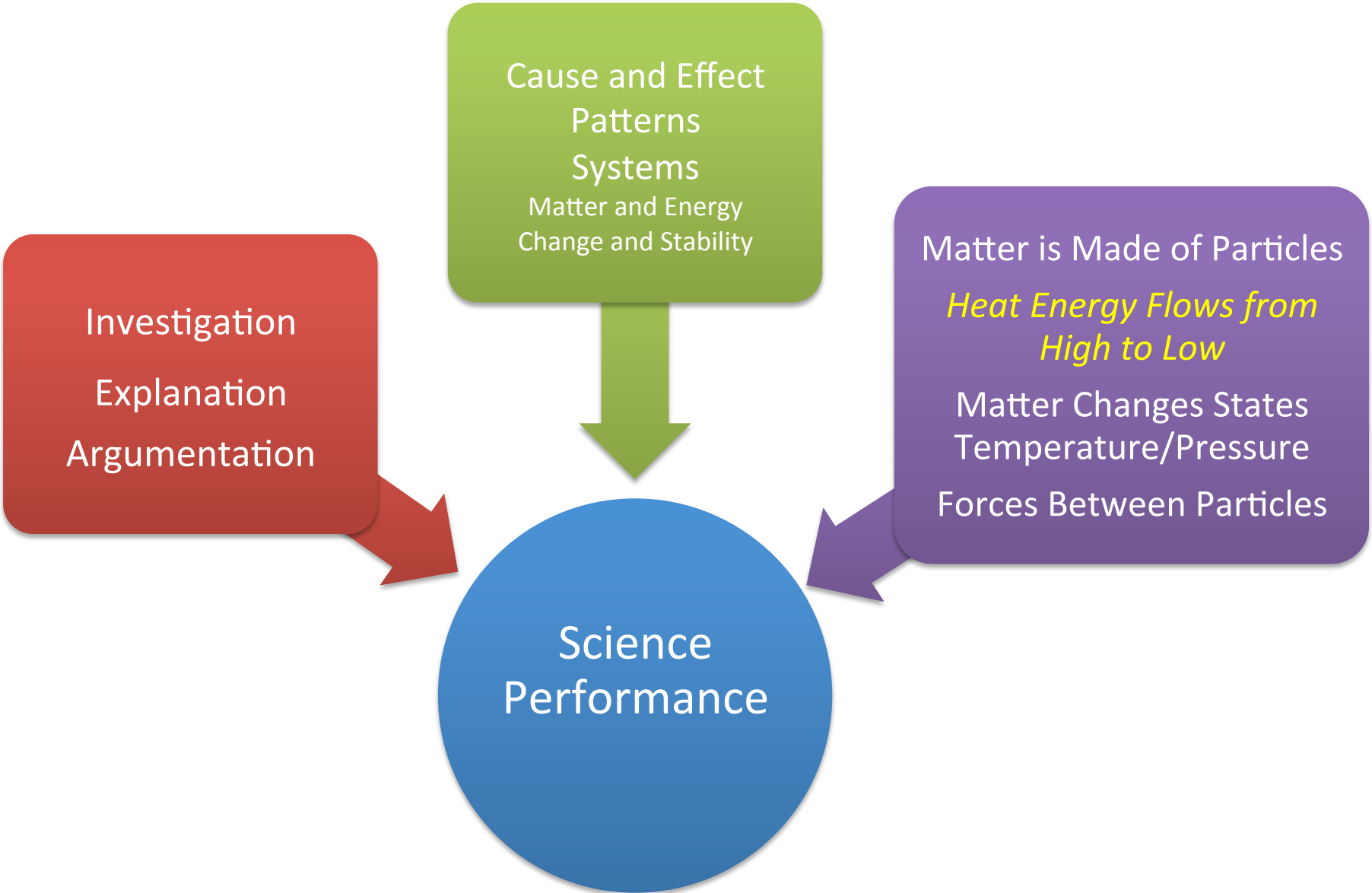
Science and Engineering Practices

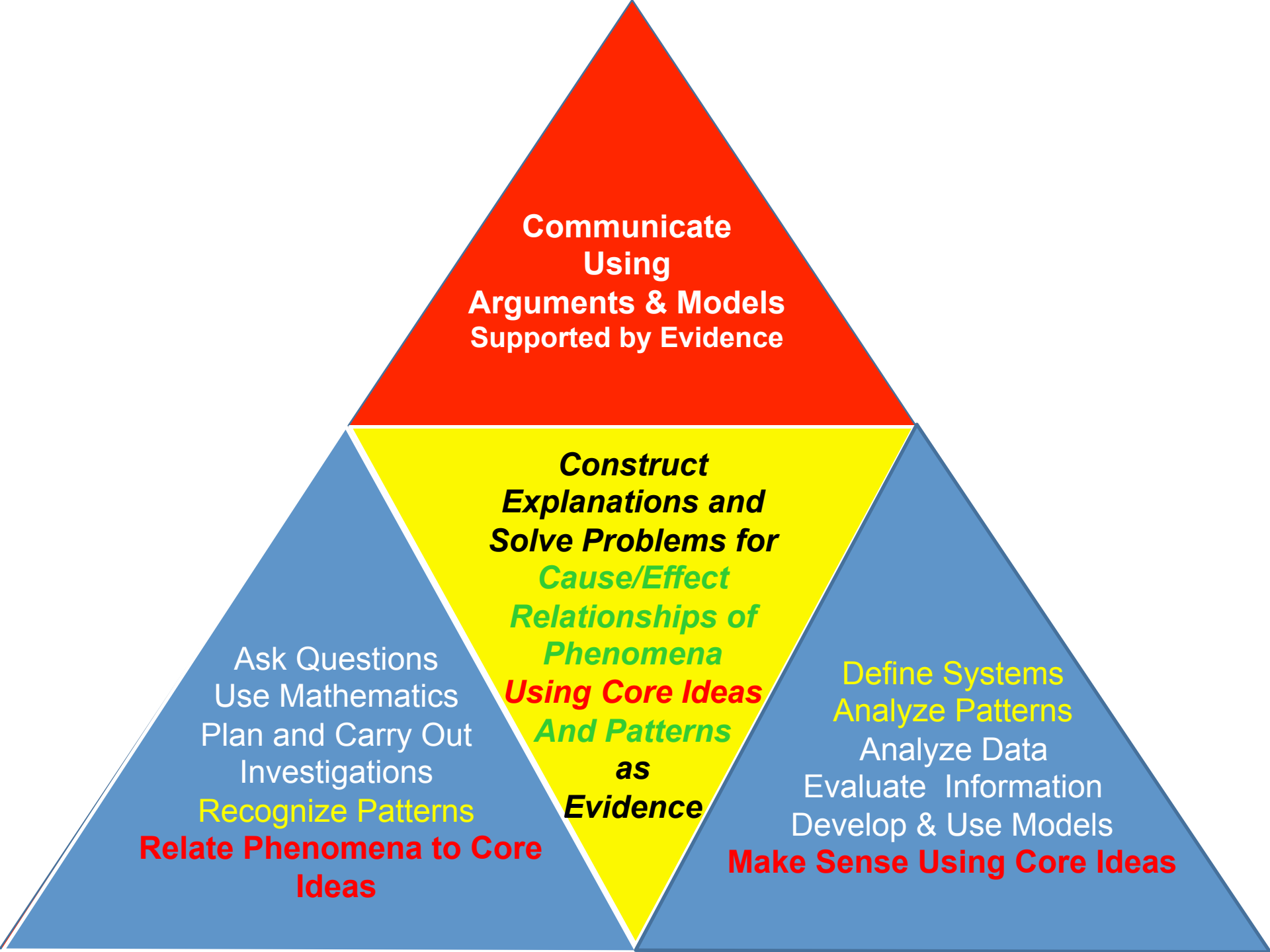
1. Asking questions (science) and defining problems (engineering)
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics, information and computer technology, and computational thinking
6. Constructing explanations (science) and designing solutions (engineering)
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

Framework Pages 41-82


Gathering
• Obtain Information
• Ask Questions/Define Problems
• Plan & Carry Out Investigations
• Use Models to Gather Data
• Use Mathematics & Computational Thinking
Reasoning
• Evaluate Information
• Analyze Data
• Use Mathematics and Computational Thinking
• Construct Explanations/Solve Problems
• Developing Arguments from Evidence
• Use Models to Predict & Develop Evidence
Communicating
• Communicate Information
• Argue from Evidence (written & oral)
• Use Models to Communicate

Performance – Water Revisited




Communicate
Using
Arguments & Models
Supported by Evidence
Construct
Explanations and
Solve Problems for
Cause/Effect
Relationships of
Phenomena
Using Core Ideas
And Patterns
as
Evidence
Ask Questions
Use Mathematics
Plan and Carry Out
Investigations
Recognize Patterns
Relate Phenomena to Core
Ideas
Define Systems
Analyze Patterns
Analyze Data
Evaluate Information
Develop & Use Models
Make Sense Using Core Ideas

Science and Engineering Practices

Performance: Explanations Using Evidence

Science and Engineering Practices

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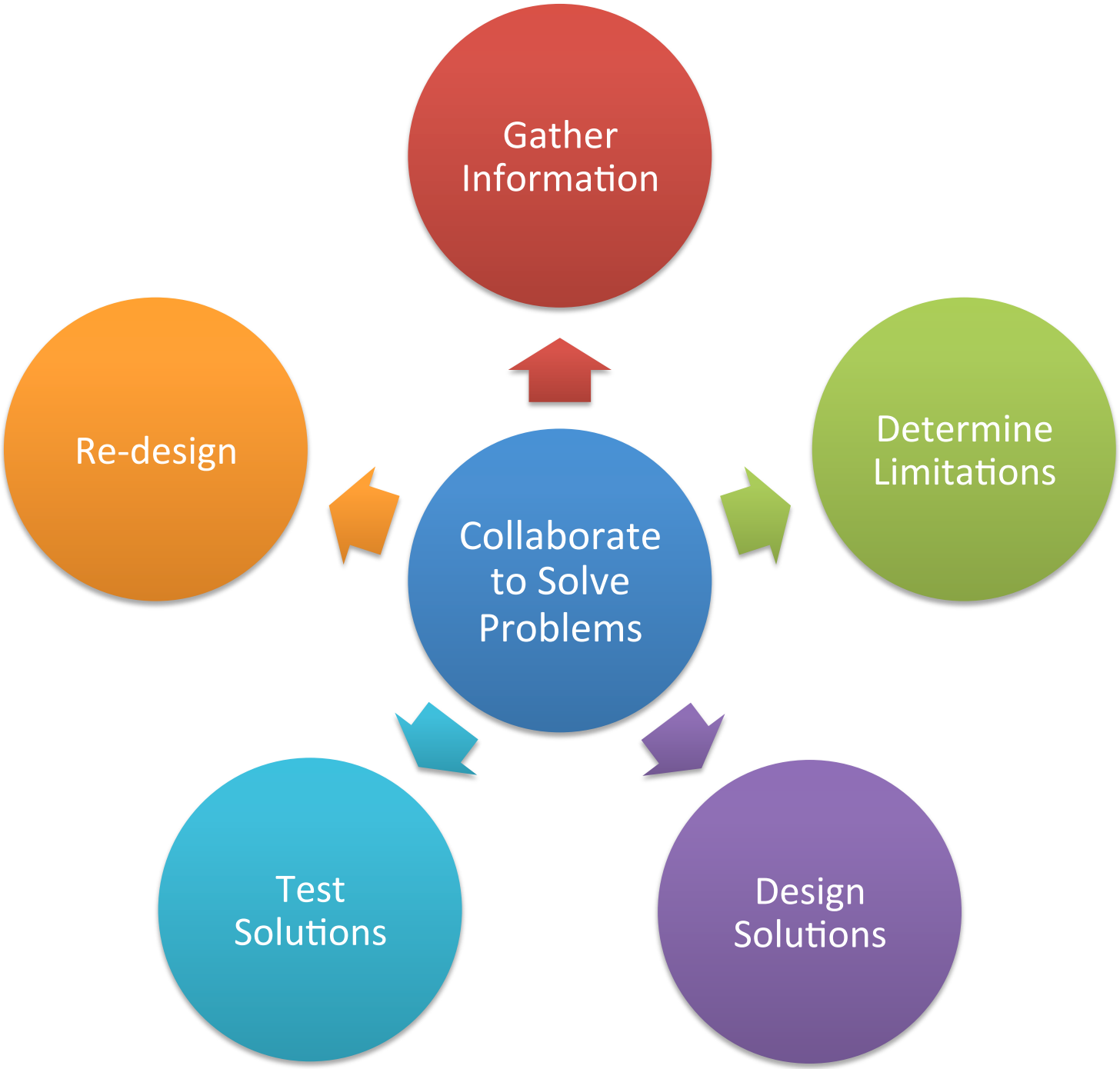

Gather Information
Determine Limitations
Design Solutions
Test Solutions
Re-design
Collaborate to Solve Problems

Similarities and Differences

Scientific Inquiry	Engineering Design
Ask a question	Define a problem
Obtain, evaluate, and communicate technical information	Obtain, evaluate, and communicate technical information
Plan investigations	Plan designs and tests
Develop and use models	Develop and use models
Design and conduct tests of experiments or models	Design and conduct tests of prototypes or models
Analyze and interpret data	Analyze and interpret data
Use mathematics and computational thinking	Use mathematics and computational thinking
Construct explanations using evidence	Design solutions using evidence
Engage in argument using evidence	Engage in argument using evidence

Adapted from A Framework for K-12 Science Education (NRC, 2011)

Science and Engineering

- Define Problem
- Determine Limitations
- Collaborate to Design Solutions
- Test Solutions
- Re-design
- Re-test
- Share Solutions

Performance: Developing Models to Support Explanations

Group Performance

Investigate how an airplane (glider) flies.

1. Individually Explore Solutions: Using a sheet of copy paper, design and build a paper airplane capable of flying a horizontal distance of 2X meters when you drop it from a height of X meters. You cannot throw the plane, only drop it.
2. In groups of three: Collaborate to solve the problem of flying a glider two times as far as the height from which it is dropped.
3. Formulate questions and investigate **explanations** for how the airplane flies.
4. Develop a **model** to show the forces on the airplane.
5. Develop **evidence** to support your **explanations.**
6. Write the steps of the engineering design process your group followed.

Individual Performance

7. Write in your journal, or on note paper, your **explanation** that may be used to explain this phenomena to others. Include **evidence** to support your **explanation** for how the airplane is able to fly and **develop a model** to communicate your **explanation.**

Group Discussion

Reflection

8. Reflect on the nature of science instruction that helps students to develop **explanations** based upon **evidence** and the role of the science and engineering practices for engaging students in gathering, reasoning, and communicating science ideas.

Performance: Developing Models to Support Explanations

Group Performance

Investigate how paper floats.

1. Individually Explore Solutions: Using a sheet of copy paper maximize the float time (time it takes to fall to the ground).
2. In Groups of Three: Collaborate to solve the problem of float time.
3. Formulate questions and investigate **explanations** for how the paper floats.
4. Develop a **model** to show the forces on the paper.
5. Develop **evidence** to support your **explanations.**

Individual Performance

6. Write in your journal, or on note paper, your **explanation** that may be used to explain this phenomena to others. Include **evidence** to support your **explanation** for how the paper floats slowly to the ground and **develop a model** to communicate your **explanation.**

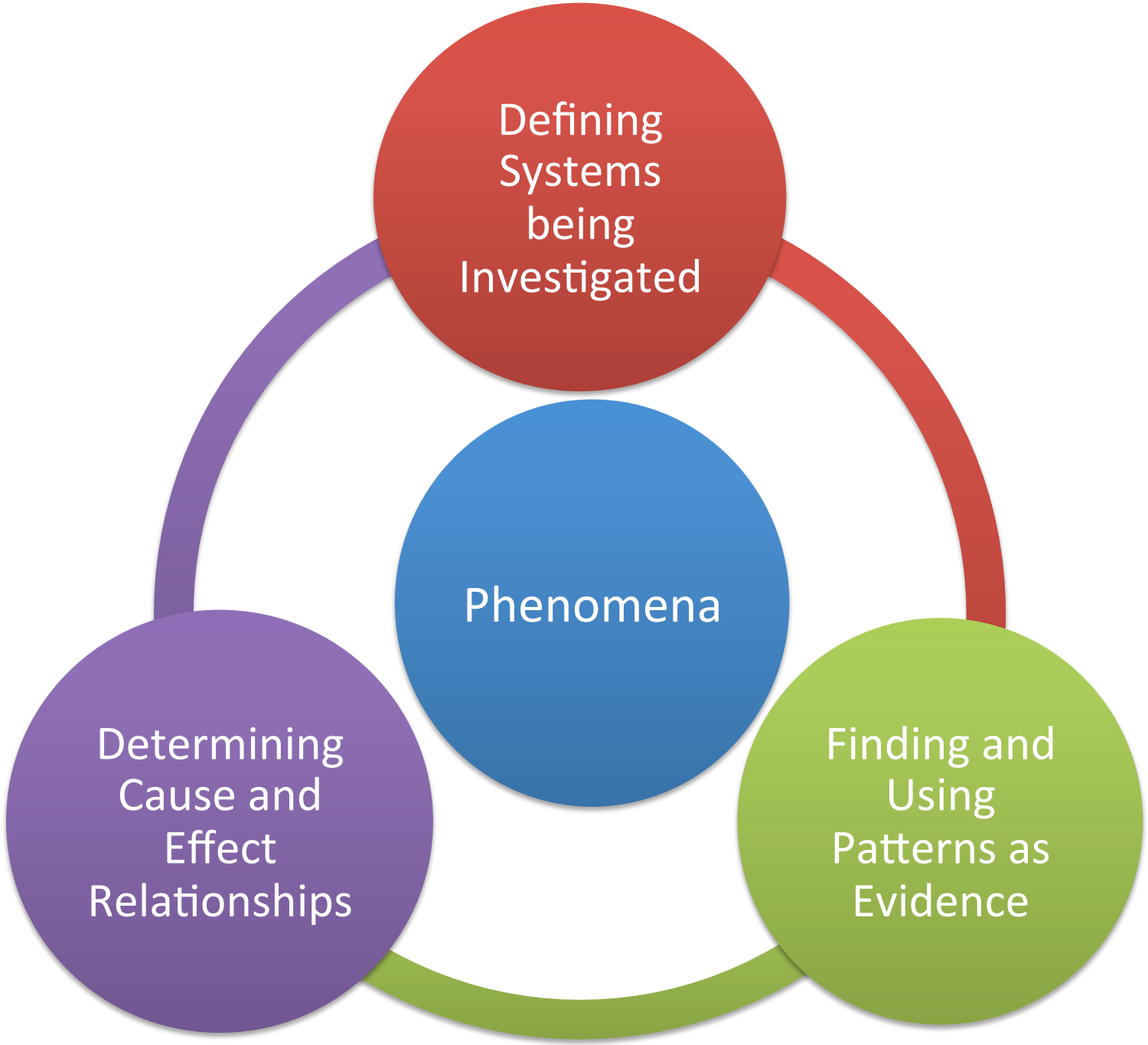
Group Discussion

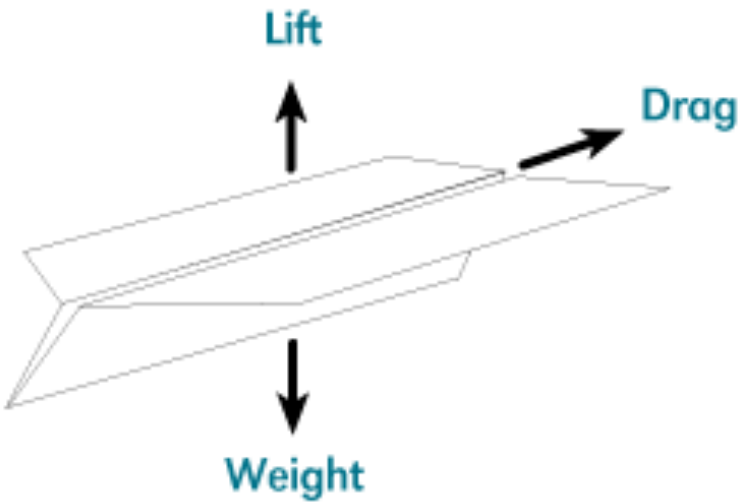
Reflection

7. Reflect on the Core ideas that help you make sense of how to maximize float time.

Evidence to Support Explanations

- What distinguishes science from other ways of knowing is the reliance on evidence as central to science.
- Value and use science as a process of obtaining knowledge based on empirical evidence.

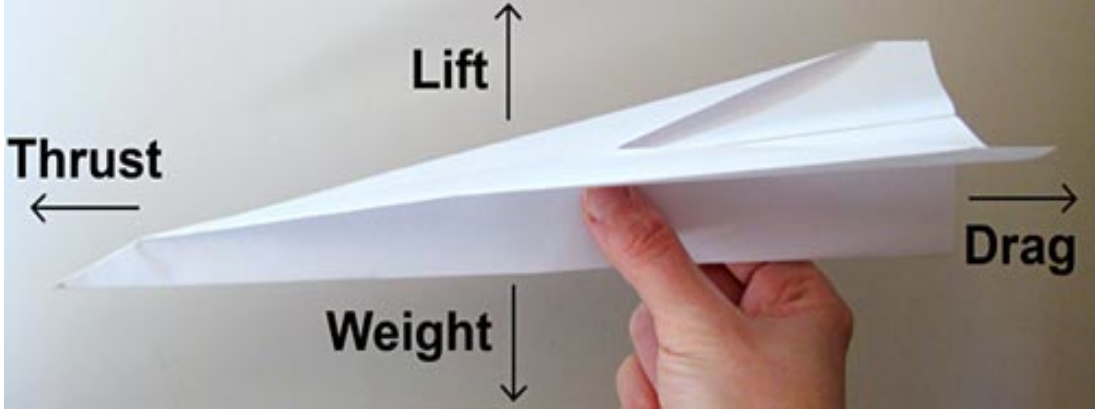

Defining Systems being Investigated
Phenomena
Finding and Using Patterns as Evidence
Determining Cause and Effect Relationships



Drag is the aerodynamic force that opposes an aircraft's motion through the air.

Lift is the force that holds an aircraft in the air.

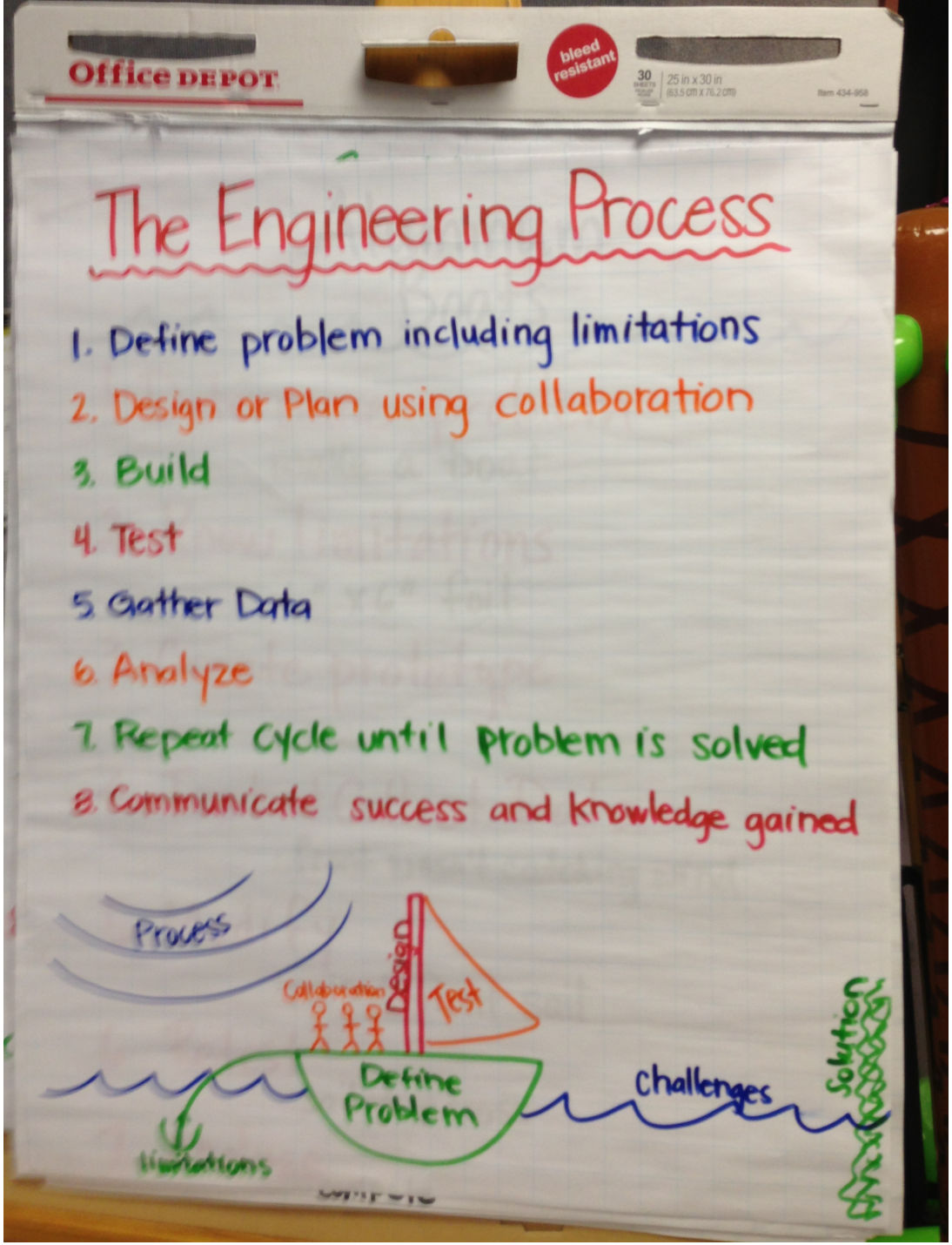
Weight is a force caused by the gravitational attraction of the Earth.



Thrust & Lift

"Thrust" and "lift" are two other forces that help your plane make a long flight. Thrust is the forward movement of the plane. The initial thrust comes from the muscles of the "pilot" as the paper airplane is launched. After this, paper airplanes are really gliders, converting altitude to forward motion.

Lift comes when the air below the airplane wing is pushing up harder than the air above it is pushing down. It is this difference in pressure that enables the plane to fly. Pressure can be reduced on a wing's surface by making the air move over it more quickly. The wings of a plane are curved so that the air moves more quickly over the top of the wing, resulting in an upward push, or lift, on the wing.



Engineering Design Process may be interpreted differently for the classroom.

NGSS – MS Engineering Design

- MS-ETS1-1. Define the criteria and constraints of a problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
- MS-ETS1-2. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
- MS-ETS1-3. Analyze data from tests to determine **patterns** among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.
- MS-ETS1-4. Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

Examples: Science and Engineering Performances from NGSS Assessment Standards

- Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms.

- Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.

- Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.

- Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects. (Cause and Effect)

Discussion

Thank you,

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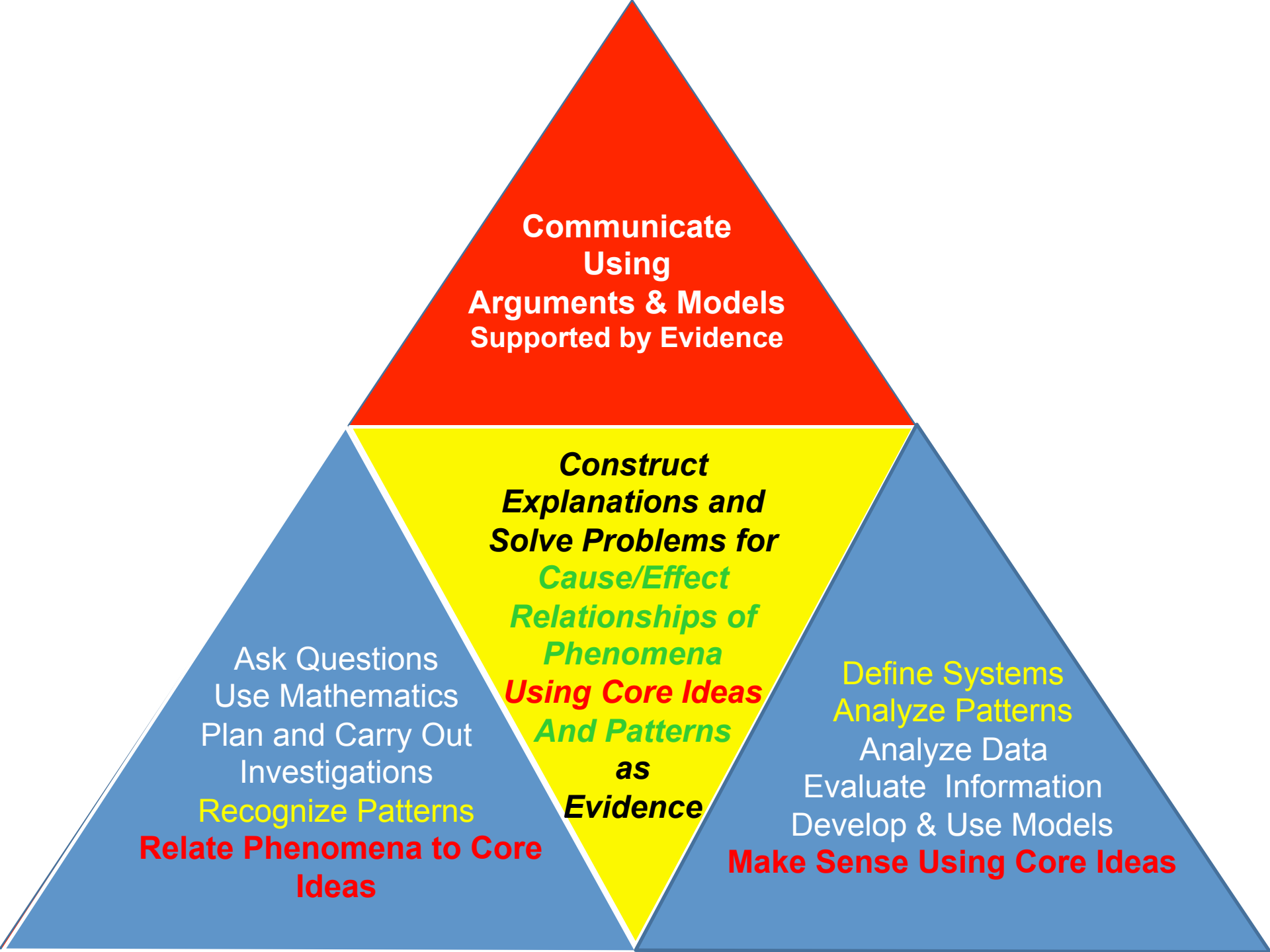
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Linking Practices and Core Ideas

1. Using practices to gather
    a. Gather information
    b. Plan and carry out investigations to collect data
    c. Analyze data
2. Using practices to reason
    a. Construct explanations and solve problems supported by evidence (Core Ideas can be used as evidence)
    b. Using models to make sense of Core Ideas
3. Communicate
    a. Develop and use arguments supported by evidence (Core Ideas are evidence)
    b. Communicate ideas (Core Ideas are ideas)

Discussion

Thank you,

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Useful Web Sites

Next Generation Website

- www.nextgenscience.org

Framework and NGSS PDF
or purchase hard copies at:

- www.nap.edu

Access the NGSS easily by installing the NGSS app on your tablets or phones. You can download the app at:

- https://itunes.apple.com/us/app/next-generation-science-standards/id683491579?mt=8